Uranium Energy Corp (UEC)

Goliad Project

Production Area Authorization Application for:

Production Area-1 (PA-1)

August 27, 2008

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Introduction

Uranium Energy Corp (UEC) applied to the Texas Commission on Environmental Quality (TCEQ) for a permit to authorize in situ recovery of uranium. The permit application was filed on August 9, 2007. UEC's permit application also included a request for an aquifer exemption covering a portion (approximately 424 acres) of the proposed 1139 acre permit area. Following a comprehensive review, TCEQ issued a proposed Final Draft Permit (Area Permit NO. URO3075) on June 17, 2008. The required 30 day public notice period was completed on July 25, 2008. At this point, TCEQ is completing its response to comments.

Subsequent to filing the mine permit application, UEC began developing all of the required elements for its first Production Area Authorization (PAA) Application. Four initial production areas were identified in the Area Permit Application; however, the order in which they would be mined had not then been finalized. Of the four production sands (Sand A, Sand B, Sand C and Sand D) presented in the Area Permit Application, on-going evaluation of the project has resulted in a decision to seek a PAA for Sand B. Applications for the other production sands will be filed as soon as UEC can complete the wells and technical evaluations needed for those areas. With respect to the first production area (PA-1), the following sections provide a detailed discussion on the site-specific geology, hydrology and water quality characteristics.

1.0 Project Site

1.1 Permit Area

UEC's proposed Goliad Project is located in Goliad County. Figure 1-1 shows the general project location with respect to other Texas counties. A more detailed project location map (see Figure 1-2 in Appendix B) shows the project location with respect to various physical and cultural features within Goliad County. As can be seen from Figure 1-2, the project is located in the northern-most reaches of the county, approximately 13 miles north of the community of Goliad.

The project site is in a rural setting which is relatively remote from major population centers. The immediate area is sparsely populated, and land use is devoted primarily to agricultural activities and the energy sector (oil/gas operations and uranium exploration). The nearest population centers include: (1) Cuero which is in Dewitt County located approximately 18 miles north of the project area; (2) Goliad which is approximately 13 miles south of the project site; and (3) Victoria which is located in Victoria County is approximately 27 miles east of UEC's site. There are no major municipal water supply wells within 5 miles of the project site.

1.2 Initial Production Areas

Figure 1-3 (see Appendix B) is a large scale map showing the permit area and initial production areas with respect to the following:

- The topography of the site and adjacent areas;
- The proposed process plant location;
- The proposed waste disposal well locations;
- Faults;
- The proposed aquifer exemption area; and
- Various cultural features such as roads, oil and gas wells, stock tanks, wind mills, gravel pits, residences, etc.

1.3 Production Area-1 (PA-1)

Previously referenced Figure 1-3 (see Appendix B) shows the location of PA-1 with respect to the permit boundary, the proposed aquifer exemption boundary and other project area features.

Figure 1-2 General Project Location

Additional details such as Mine Area size, Production Area size, monitor well locations, baseline well locations, average depth to the production zone and the elevation, referenced to Mean Sea Level, (MSL) of the production zone are given on Figure 1-4 Production Area Map. Using data from 239 exploration holes, the production zone's depth from surface is given in Table 1.1, and its elevation (top and base with respect to MSL) is shown in Tables 1.2 and 1.3, respectively.

A review of Figure 1-4 shows that the Mine Area of PA-1 encompasses approximately 94 acres while the Production Area comprises just over 36 acres. There are 22 Production Zone Monitor Wells (BMW-1, 2, 3 … 22) that encircle the proposed Production Zone. Interior wells labeled PTW-1 through PTW-14 (Pump Test Wells) and RBLB-1, 3, 4 and 5 (Regional Baseline Wells) are completed in the Production Zone. A fourth set of wells labeled as OMW-1 through OMW-9 are completed in the overlying Sand A. Lastly, the revised map shows two proposed Guard Wells (GW-1 and GW-2), which will be completed in the production zone. The wells serve the following purposes:

(1) To provide baseline water quality information within the Mine Area, Production Area and overlying aquifer;
(2) To provide a basis for conducting hydrologic testing of the aquifers; and
(3) To provide a pattern of monitor wells for near-future production and restoration activities.

The number and placement of monitor and baseline wells conform to and exceed the requirements given in 30 TAC §§§ 331.82, 103 and 104. For example, according to § 331.82(g) designated monitor wells must be at least 100 feet inside any permit boundary, unless excepted by written authorization from the Executive Director; the nearest designated monitor well in PA-1 to the Mine Permit Boundary is approximately 225 feet inside the western boundary. Distances from all other parts of the monitor well ring to the Mine Permit Boundary significantly exceed the 100 foot requirement (see Figure 1-3 in Appendix B).

In addition to following the 100-foot requirement, the monitor well ring was designed to satisfy the requirements given in § 331.103(a). The monitor wells are within 400 feet of the Production Area; they are no greater than 400 feet apart; and the angle formed by lines drawn from any production well to the two nearest monitor wells does not exceed 75 degrees.

The number of monitor wells that must be completed in the first overlying aquifer is specified in § 331.103(b). According to the rule, a minimum of one well per four acres of production area is required; monitor wells OMW-1 through OMW-9 satisfy this coverage requirement. With respect to production zone monitor well density, revised rule §331.104(c) specifies that a minimum of 5 wells, or 1 well per 4 acres of production area, whichever is greater, shall be completed in the production zone. The production zone monitor well density in PA-1 exceeds the minimum requirement by a factor of 2. Figure 1-4 shows there are 18 production zone monitor wells distributed over 36 acres of production area, or 1 well per 2 acres. The addition of 2 Guard Wells inboard of BMW-19 and BMW-20 provides even more groundwater monitoring coverage than is required by the rules.

Figure 1-4 Production Area Map

Table 1.1

Table 1.2

Table 1.3

Referring again to Figure 1-4, it can be seen that PA-1 has 36 acres of production area and 9 overlying monitor wells. The distribution of the wells above the 36 acre production zone provides significant coverage for monitoring purposes. The well pattern also served to allow baseline water quality to be assessed throughout the overlying 36 acre zone.

With respect to characterizing Production Area baseline water quality, § 331.104(a)(2) requires the collection of a minimum of one or more samples from at least 5 designated production zone wells. In developing Production Area baseline water quality, UEC exceeded the minimum requirement by completing 17 wells. Sample analyses from 10 of the wells are included in this submission. Seven additional wells are scheduled to be sampled in early September. TCEQ is planning to collect samples from some of the baseline wells during the September sampling period. UEC plans to supplement the production zone water quality baseline data with results from the upcoming sampling.

Expanding the number of samples throughout the Production Area will significantly improve the accuracy of baseline conditions, and this in turn will allow for significant improvement in reaching the goals set out in the required Restoration Table.

As described above on page 1-4, UEC actually installed 8 additional production zone baseline wells, and thus there is a total of 18 monitor wells in the production area.

2.0 Surface and Mineral Ownership

2.1 Ownership Adjacent to the Permit Area

Surface and mineral ownership adjacent to the permit boundary was researched through county courthouse records. Owners and their contact information are summarized in Tables 2.1 and 2.2., and Figure 2-1 shows the location of the surface and mineral owners with respect to UEC's Permit Boundary.

2.2 Ownership within the Permit Area

UEC retained a professional land surveyor, Black Gold Surveying & Engineering, Inc., to survey the Permit Boundary of the project site. The results of the survey are given in Figure 2-2. As can be seen from the map, the 1140.42 acre (more or less) permit boundary is presented on the Peter Gass Survey, A-129, the Squire Burns Survey A-69 and the H.M Frazier Survey A-123 and Squire Burns Survey A-70. Surface and mineral owners within the surveyed Permit Area are shown on Figure 2-3, and their contact information is listed in Table 2.3.

UEC purchased a 17 acre track of land within the permit area in 2008; the location of the tract is shown on previously referenced Figure 2-3. Black Gold Surveying & Engineering conducted a survey of the land and provided the legal description given on page 2-14. Figure 2-4 (see Appendix B) is a survey plat of the property.

Table 2.1 Adjacent Surface Ownership

Table 2.2 Adjacent Mineral Ownership

Figure 2.1 Adjacent Surface and Mineral Ownership

Figure 2.2 Permit Area Survey

Table 2.3 Ownership within the Permit Area

1	Gary Halepeska 962 Bluntzer Rd. Goliad, TX 77963
2	Elder Abrameit 1005 FM 622 Victoria, TX 77905
3	Margaret Braquet c/o Sydney Braquet 1324 Cortland Street #1 Houston, TX 77008
4	David Cheek 14319 North U.S. Hwy 183 Yorktown, TX 78164
5	R.G. Stanford 695 Stanford Lane Victoria, TX 77905
6	Sharon Schrade Bryan 8847 Wood Lane Madisonville, TX 77864
6	Diana Schrade Slafka 12800 Plymouth Circle Anchorage, AK 99516
7	Uranium Energy Corp 9801 Anderson Mill Road, Suite 230 Austin, Texas 78750

Note: See Figure 2-3 for owner location.

3.0 Production Area Geology and Hydrology

3.1 Geology

The permit area is located within the outcrop of the Goliad Sand. The Goliad Sand generally consists of up to 500 feet of light colored sand and sandstone (typically impregnated with caliche) interbedded with clay and gravel. In Goliad County, the subsurface strata generally strike from southwest to northeast and dip to the southeast at approximately 20 feet/mile near the outcrop, and up to 70 feet/mile away from the outcrop (Dale, et al., 1957).

As will be seen in the sections to follow, the descriptive surface and subsurface geology will mirror that given in UEC's Mine Permit Application (MPA), and the same can be said for site-specific hydrology. Because of the expanded database (e.g., the completion of a significant number of monitoring and baseline wells; additional baseline water quality testing; additional exploration/delineation holes; and the completion of hydrologic testing), the subsequent discussions provide a higher level of information and a refinement of the Production Area (PA-1).

As described in Chapter 1.0, the Mine Area (the area encompassed by the Monitor Well Ring) in PA-1 is approximately 94 acres and the Production Area is a little over 36 acres. In preparing a detailed geologic study of PA-1, four dip and strike cross-sections were constructed. The locations where the cross-sections transect PA-1 are shown on Figure 3-1 Cross-section Index Map (see Appendix B). Figure 3-1 also identifies the exploration holes and wells that were used in constructing the cross-sections.

3.1.1 Stratigraphy and Lithology

Within the permit area, the Goliad Formation consists predominantly of fluvial facies, having a relatively high sand content. The up dip parts of the sand axes contain abundant amounts of coarse grained sand and gravel deposited by braided streams and grade down dip into meanderbelt deposits. Farther down dip, the fluvial system grades into deposits of a wave-dominated deltaic system. Generally, the relict river systems to the north of the San Antonio River carried higher sand loads than the relict river systems to the south (Solis, 1981).

The Goliad Formation is approximately 400 feet thick in the permit area, and it is divided into four discrete sand units: Sand A, Sand B, Sand C, and Sand D. Each of the sand units, with the exception of a portion of Sand A across the Northwest Fault, is overlain and underlain by a relatively thick clay/shale layer throughout the permit area. Each of these sand units appears to constitute a discrete individual aquifer unit within the permit area. Figures 3-2 through 3-5 are detailed strike and dip oriented cross-sections through PA-1 which show the stratigraphical, lithological, and structural relationships of the individual sand units. Individually, each of the sand units is confined above and below by a clay/shale layer. Continuity of the confining zones establishes the basis for sand unit definition. The confinement discussed above was thoroughly evaluated by hydrologic pump tests, and the results confirm the effectiveness of the extensive confining layers across PA-1 (see Chapter 4.0, Hydrologic Testing).

Sand A is the upper-most sand in the permit area. In the MPA it was shown that Sand A is overlain by a clay/shale confining layer which has a thickness ranging from about 50 to 70 feet. With the exception of where it outcrops across the Northwest Fault, the clay/shale confining layer is persistent throughout the permit area on the down thrown of the Northwest Fault where production is being planned.

The approximate thickness of Sand A in PA-1 ranges from about 45 to 70 feet (see cross-sections).The upper and lower boundaries of Sand A are discernible on electric logs, and generally quite clear in drill cutting samples. As indicated on the cross-sections the unit is pervasive throughout PA-1. The average depth to the base of Sand A is 99 feet below ground level (BGL) and the average thickness is 65 feet.

Sand B is the next lower sand unit below Sand A. The average depth to the top of Sand B is approximately 152 feet BGL. Sand B, the production zone of PA-1, ranges in thickness from 30 to 50 feet across PA-1 (see Figure 3-6 Net Sand Map in Appendix B). The confining layer between Sand A and Sand B is shown on Figure 3-7 Isopach Map – Thickness of Overlying Confining Layer (see Appendix B). From this figure, it can be seen that the two sands are isolated from each other by a substantially thick clay/shale barrier ranging between 40 and 50 feet in thickness.

Referring again to the cross-sections, it can be seen that Sand C is the third unit, and a proposed production zone, encountered below the surface. The average depth to the top of Sand C is 233 feet BGL and the average depth to the base of Sand C is 269 feet BGL, resulting in an average thickness ~~is~~ 36 feet. Sand C is isolated from overlying Sand B by approximately 20 to 30 feet of clay/shale (see Figure 3-8 in Appendix B).

Sand D is the second underlying sand unit below Sand B. As demonstrated in the MPA, Sand D is isolated from the overlying Sand C and the underlying Lagaro Formation by shale/clay confining layers. A number of the logs in the cross-sections show the Lagarto Clay at the base of Sand D. The average depth to the base of Sand D is 385 feet BGL and its average thickness is 80 feet.

The Lagarto Formation (aka Lagarto Clay) of the Fleming Group (Miocene) underlies the Goliad in the permit area and extends from the base of the Goliad to a depth of approximately 1600 feet BGL. The upper Lagarto looks very similar lithologically to the Goliad. In general, the upper part of the Lagarto is sandier than the middle and lower portions. The sands in the upper portion of the Lagarto are considered part of the Evangeline Aquifer System; however the sands are separated from the overlying Goliad by relatively thick clay layers and probably constitute a discrete aquifer system comprising the first underlying aquifer. In general, the Lagarto is described as clay and sandy clay with intercalated beds of sand and sandstone (Dale, et al., 1957).

The Lagarto is underlain by the Oakville Sandstone (Fleming Group-Miocene). The Oakville unconformably overlies the Catahoula Tuff and crops out to the west and northwest of Goliad County. The Oakville consists of up to 700 feet of crossbedded sand and sandstone interbedded with lesser amounts of sandy, ashy, bentonitic clay.

3.1.2 Structural Geology

As indicated on previously referenced cross-sections and project maps, two strike oriented (southwest to northeast) normal faults are present in the permit area. Based on limited discernable fault intercepts on geophysical logs from exploration holes drilled near the faults, both faults have been determined to be high angle with dips of 65 to 70 degrees. Consequently, the faults are mapped primarily based on stratigraphic offset of correlative beds as indicated on the cross-sections. The fault in the northwest portion of the project area is downthrown on the south side of the fault and demonstrates variable offset but generally indicates approximately 75-80 of the Sand A structural surface.

The fault in the southeast portion of the project area is downthrown to the north side, thus forming a graben structure with the northwest fault through the middle of the mine permit area. Displacement along this fault is approximately 35 feet.

The proposed PA-1 production area is situated entirely within the graben and there are no identified structural features associated with the proposed PA-1 area. Both faults completely traverse the mine permit area and thus their extent in the north-south direction has not been delineated.

3.2 Production Area Hydrology

The following is a brief overview of site hydrology along with an identification of the various sands and confining layers. The purpose of the overview is to provide a general background to site-specific conditions. Because hydrologic pump testing was completed for PA-1, considerably more detail of the site's hydrologic properties is given in Section 4.0 Hydrologic Testing.

It was discussed in the MPA that groundwater movement across the site is generally to the southeast and that the hydraulic gradient is approximately 5.5 feet per mile. It was also estimated in the MPA that groundwater flow is approximately 6.7 feet per year. Additional information from the pump tests show that groundwater flow is approximately 7.9 feet per year.

It was stated in the section on geology herein and in the MPA that on a regional basis the Goliad may be viewed as a single, large aquifer system. It was also noted in the MPA that on a site-specific level (i.e., the permit area) each of the four sands functions as an isolated aquifer; the results of the hydrologic pump test clearly show the isolation of the four sands from each other. Following is a summary description of the aquifers present within the project area.

At UEC’s project site, the Goliad Sand outcrops at the surface and is part of the first aquifer unit encountered in the subsurface (previously referenced Sand A). As described in the MPA, the Goliad is entirely contained within the Evangeline Aquifer; however the aquifer unit also extends into sands within the upper portion of the underlying Fleming Group. The Evangeline is typically wedge shaped and thickens significantly toward the coast. The Evangeline has a high sand-clay ratio and is a prolific aquifer moving towards the coast (Baker, 1979). In Goliad County, the Goliad Sand consists of up to 500 feet of predominantly sand containing some clay and gravel beds and is reported to yield small supplies of variable quality water to wells (Dale, et al., 1957).

The Burkeville Confining System lies beneath the Evangeline Aquifer in the regional study area. The Burkeville is a hydrostratigraphic unit that separates the Evangeline Aquifer from the underlying Jasper Aquifer. The Burkeville generally corresponds to the Lagarto Clay of the Fleming Group and contains a relatively large percentage of silt and clay compared to the overlying and underlying aquifers and retards the interchange of water between the aquifers (Baker, 1979).

In Goliad County, the Lagarto Clay consists of 800 to 1,200 feet of clay and sandy clay containing interbedded layers of sand and sandstone capable of yielding moderately large quantities of water to wells (Dale, et al., 1957).

The Jasper Aquifer lies beneath the Burkeville Confining System in the Texas Coastal Plain region. In the regional study area, the base of the Jasper Aquifer corresponds with the base of the Oakville Sandstone of the Fleming Group and generally denotes the base of the USDW.

The uppermost aquifer within the UEC Permit Area is the Evangeline Aquifer. In general, the Evangeline Aquifer consists of the Goliad Sand in the regional study area.

However, the boundary of the Evangeline may extend into the sands of the underlying Lagarto Clay of the Fleming Group. The Goliad Sand is reported to unconformably overlie the Lagarto Clay; however the basal sands of the Goliad are hard to distinguish from the sand beds within the upper portion of the Lagarto (Dale, et al., 1957). In general, the Goliad Sand consists of up to 500 feet of predominantly light colored, fine to coarse grained, sand and sandstone with interbedded clay and gravel. The sand and gravel are typically impregnated and cemented with caliche, which imparts the characteristic light color to the sands. The Goliad is reported to yield small quantities of variable quality water to wells in Goliad County. In the UEC permit area the base of the Goliad occurs at an approximate depth of 400 feet BGL.

The four sands (Sand A, Sand B, Sand C and Sand D) in the mine area were described in Section 3.1.1 in terms of their depths, elevations, thicknesses and confining layers and therefore the descriptions will not be repeated here.

The Lagarto Clay (Fleming Group) is the next stratigraphic unit encountered beneath the Goliad Sand. The Lagarto conformably overlies the Oakville Sandstone in Goliad County. The Lagarto is reported to consist of up to 1200 feet of dark colored clay and sandy clay with intercalated beds of sand and sandstone. In the permit area, the sand beds contain fresh water, which may be of better quality than that found in the overlying Goliad (Dale, et al. 1957). In general, the upper part of the Lagarto is sandier than the middle and lower portions. The sands in the upper portion of the Lagarto are considered to be part of the Evangeline Aquifer System; however the sands are separated from the overlying Goliad by relatively thick clay layers and probably constitute a discrete aquifer system comprising the first underlying aquifer. The middle and lower portions of the Lagarto constitute the Burkeville Confining System hydrostratigraphic unit described previously.

However, discrete sands within the lower and middle Lagarto may contain large supplies of fresh water, which is reported to be under artesian pressure in the middle part of Goliad County (Dale, et al.1957). The town of Goliad, which is located approximately 14-miles to the south of the permit area, utilizes municipal water supply wells producing from the Lagarto Clay.

The Lagarto is underlain by the Oakville Sandstone. The Oakville generally comprises the Jasper Aquifer System and essentially is the base of the USDW in the proposed UEC Permit Area. The Oakville consists of up to 700 feet of cross-bedded sand and sandstone interbedded with lesser amounts of sandy, ashy, bentonitic clay (Dale, et al. 1957).

3.2.1 Water Quality Indicators

A comprehensive baseline water quality sampling program was conducted for PA-1. The Mine Area, Production Area and overlying Non-production Zone were analyzed for 26 water quality parameters. In addition, water levels recorded and poteniometric surface maps were made for the area. A full discussion on these elements of the aquifers is the subject of Chapters 5.0 and 6.0 of this Application.

4.0 Hydrologic Testing

The hydrologic testing was performed to comply with TCEQ requirements to obtain a Production Area Authorization (PAA) for in-situ uranium recovery. These requirements stipulate that hydrologic testing must be used to quantify the response of the aquifer that will be mined. PAA-1 is located in Goliad County, near Weesatche, Texas. Hydrologic testing was performed at the PAA-1 site on July 8 through July 15, 2008.

4.1 Test Methodology, Procedures and Goals

The goals, test location, methodology and procedures are discussed in the sections that follow.

The first goal was to confirm that there is hydraulic communication between the monitoring well ring and the wells within the production zone sand (Sand B). This was accomplished by pumping the interior wells completed in the production zone and recording the water levels in the monitoring well ring to show that the production zone monitor wells will in fact be able to detect fluid movement from where uranium recovery is occurring (the production zone). During recovery operations, a net drawdown or "bleed" is maintained in the ore zone by producing (i.e., removing) approximately 1% more water than the amount being injected. This means that there will be a hydraulic barrier to prevent fluid from moving out of the production zone. As an added measure of safety, water quality in the monitor wells must be monitored throughout the recovery and restoration phases of the operation.

The second goal was to analyze the pumping test results. This was done to obtain data on the aquifer's hydraulic characteristics such as transmissivity, storativity, and hydraulic conductivity.

Also, if the data can be analyzed using standard hydrologic techniques, it demonstrates that the drawdown was indeed induced by the testing and not some incidental activity. Both the drawdown phase and the recovery phase of the test were recorded and analyzed.

The third goal was to determine if there is hydraulic communication between the ore sand and the overlying water-bearing zone. The area in Production Area-1 (PA-1) has only one overlying aquifer; Sand A. It is necessary to establish that there is no communication between the fluids in the ore zone and water in overlying aquifers.

4.1.1 Test Area

The PA-1 test area is shown in Figure 4-1. Figure 4-1 also shows the location of the various wells used in the test.

The pumping test wells (PTW) are completed in the Sand B which is the ore zone. This was the primary sand tested. The baseline monitoring wells (BMW) are the production zone baseline wells discussed above and are also completed in sand B. Overlying monitoring wells (OMW) are completed in Sand A which is located above Sand B and isolated from it by a confining clay/shale layer. The objective of monitoring Sand A was to confirm the presence of an effective geologic barrier to flow between the ore zone and any overlying aquifers. Regional baseline wells (RBL) are designated for each sand. Therefore, there are RBLA (Sand A) wells, RBLB (Sand B) wells, etc.

4.1.2 Overview of the PA-1 Pumping Tests

Background water levels and barometric pressure were monitored from 17:00 hours on 7/8/2008 to 11:05 hours on 7/9/2008. Following this, two separate constant rate drawdown and recovery tests were performed at the PAA-1 location. A constant rate test stresses the aquifer through time and gives a good indication of how the aquifer will respond to long term pumping.

Figure 4-1 Production Area Pump Test Wells

The first test used PTW-6 as the pumping well. The pumping test began on 7/9/2008 at 11:05 hours and ended on 7/10/2008 at 20:28 hours for a total duration of 33.4 hours. The recovery was then monitored until 15:26 hours on 7/11/2008 for a duration of 18.96 hours. During the drawdown and recovery tests, barometric pressure was monitored and water level drawdown and recovery were monitored in various wells as discussed below.

The equipment was then moved and PTW-1 was used as the pumping well. The PTW-1 pumping test began on 7/12/2008 at 10:34 hours and ended on 7/13/2008 at 20:02 hours for a total duration of 33.43 hours. The recovery was then monitored until 8:36 hours on 7/15/2008 for duration of 36.56 hours. During the drawdown and recovery tests, barometric pressure was monitored and water level drawdown and recovery were monitored in several wells as discussed below.

4.1.3 Data Acquisition and Equipment

Water level drawdown and recovery were recorded digitally and the data were downloaded to laptop computers for storage and analysis. In observation wells close to the pumping wells, water levels were recorded more frequently at the beginning of a drawdown or recovery phase. The sampling time increment was increased as the test progressed. This is because most of the water level change occurs early in the test. In the early parts of the test, water levels were recorded every 0.0273 minutes (1.64 seconds). After 5 minutes, water levels were recorded every 20 seconds. After 30 minutes, water levels were recorded every 2 minutes until the end of the test. Water levels in the baseline monitoring wells were recorded every 5 minutes because they were located farther away from the pumping well.

For the PTW-6 test, water levels in monitoring wells BMW-1 to BMW22, PTW-5, and OMW-8 and OMW-9 were monitored using In-Situ Inc. Troll units. In addition, an In-Situ Inc. Hermit unit was used to monitor the barometric pressure and the water levels in PTW-6, PTW-3, PTW-4, and RBLB-3.

Periodic manual water level measurements were made throughout the test with e-line measuring devices. These measurements were made to supplement the data and to verify that the transducers were performing adequately. In the PTW-6 test, water levels were measured manually in OMW-6 to OMW-9 and PTW-3 to 6. Manual measurements were also obtained in RBLB-1, RBLB-3, RBLB-5, and BMW-1 to 22. These manual readings were taken for quality assurance purposes to confirm the data logger measurements.

For the PTW-1 test, water levels were monitored in the following wells using In-Situ Inc. Troll units: BMW-1 to BMW22, PTW-3, RBLC-4, and OMW-2. An In-Situ Inc. Hermit unit was used to monitor the barometric pressure and the water levels in PTW-1, PTW-2, OMW-1, and RBLB-4. In the PTW-1 test, water levels were measured manually in OMW-1 to OMW-9 and wells PTW-1 to 3. Manual measurements were also obtained in RBLB-4, RBLC-3, RBLC-4, and BMW1 to 22. As in the first test, these manual readings were taken for quality assurance.

4.1.4 Pumping Equipment

For both pumping tests, a 4 inch diameter 5 horsepower pump was used. The pump was set just above the screen interval in each well. The pump was capable of pumping approximately 40 gallons per minute (gpm) at the installed depth for each test.

4.1.5 Well completions

Sand A and is in the depth range of approximately 50 to 120 feet below ground level and the OMW wells are completed within this interval. This is the only overlying sand above the production zone. Sand B wells are in the production zone. They are deeper, with typical completions in the 160 to 200 feet depth range. These wells include the pumping test wells and the production zone baseline monitoring wells.

A typical well in Sand A and B has a 9.875 inch reamed hole diameter with 5 inch inner diameter (ID) cemented casing. The completion consists of a 3 inch ID liner hung off the bottom of the casing with a section of screen. The upper part of the liner consists of a small section (approximately 2 to 7 feet) of steel blank pipe followed by a 20 feet section of 0.010 feet slotted screen.

4.2 Test Results

4.2.1 Barometric Pressure Measurements

Barometric pressure was measured during the entire PA-1 field test including both the PTW-6 and PTW-1 tests and a background measurement period prior to the PTW-6 test. Figure 4-2 shows the barometric pressure in pounds per square inch (psi) during the test. The barometric pressure was measured using an In-Situ Inc. barometer that was linked to the Hermit recording device.

From the data, the normal diurnal fluctuation in barometric pressure can be seen. Although there was a slight increase in barometric pressure early in PTW-6 test, the atmospheric pressure remained relatively constant thereafter. A weak low pressure system moved into the area just after the start of the PTW-1 pumping phase.

4.2.2 Background Water Level Measurements

PTW-6 Test Background Water Level Measurements

Prior to the start of the first test at PTW-6, background water levels were recorded at 5 minute intervals starting on 7/8/2008 at 17:00 hours and ending at 7/9/2008 at 11:05 hours. Background water levels were recorded in BMW wells 1 through 22, in PTW-5, and overlying Sand A monitoring wells OMW-8 and OMW-9. The change in the water level relative to the initial measurement is shown in Figure 4-3.

Figure 4-2

Figure 4-3

From this figure, it can be concluded that there was a small but definite trend of water level decline in all but two of the wells over the 18 hour monitoring period. There was a small rise in water levels in BMW-3 and BMW-19. The maximum change in water levels was approximately 0.05 feet (0.6 inches) with most values in the 0.02 feet (0.24 inch) range. This small amount of change is considered to be negligible and to have an insignificant effect on the interpretation of the test results. The background water level changes are attributed to small changes in barometric pressure as discussed below.

PTW-1 Test Background Water Level Measurements

Background water levels were also obtained prior to the PTW-1 pumping and recovery tests. This information was not used in the analysis that follows because water levels were perturbed due to the prior PTW-6 test and therefore, they may not be representative of true background conditions in the Sand B aquifer.

4.2.3 Barometric Efficiency of the Sand B Aquifer

Figure 4-3 also shows the inverted change in barometric pressure from the start of measurement as recorded prior to the PTW-6 test. The delta barometric pressure data were inverted and converted to feet of water for ease of comparison. The pressure data were inverted because of the opposite relationship that exists between water levels and barometric pressure in a confined aquifer. As the barometric pressure increases, water levels decline (and vice versa) in a well completed in a confined aquifer. The water level changes generally follow the pattern of the change in barometric pressure with no or only a very small time lag. There is not a one to one correspondence, however.

The barometric efficiency, BE, is the ratio of the water level change and the change in barometric pressure (Todd, 1980; Freeze and Cherry, 1979; Domenico and Schwartz, 1990):

$$BE = \Delta h \text{ (0.4335 psi/ft)} / \Delta Patm$$

Where:

Δh = change in water level (feet)

$\Delta Patm$ = change in atmospheric pressure (psi)

BE = barometric efficiency (fraction)

0.4335 psi/ft = conversion factor

The barometric efficiency for Sand B was determined as follows. The background data in Figure 4-3 were analyzed and it was determined that the water levels in RBLB-3 were representative of the average water level change. The water level changes in RBLB-3 were plotted along with the inverted barometric pressure change (converted to water). A multiplicative factor representing the barometric efficiency was applied to the barometric data until a good match was obtained to the amplitude of the water level change in RBLB-3 (Figure 4-4). This methodology is commonly used as documented by Todd (1980) and Domenico and Schwartz (1990).

The barometric efficiency of the Sand B aquifer was determined to be 0.60. This means that 60% of the change in barometric pressure is recorded in the Sand B aquifer as an opposite water level response.

Figure 4-4

PTW-6 Test Barometric Pressure Corrections

Figure 4-5 shows the trend of the barometric pressure during the PTW-6 drawdown and recovery tests. A linear regression is provided with the line fit shown on the figure:

$$y = 1.0E\text{-}5x + 14.653 \text{ psi}$$

where y = barometric pressure, and x = elapsed time in minutes.

The overall trend shows a slight increase in barometric pressure over the time of the test. The increase is very small as evidenced by the slope of the line, 1.0E-5. During the course of the test, the atmospheric pressure increase would cause a small increase in the water level drawdown and a small decrease in the water levels during recovery.

Using the BE of 0.6 derived above, this average trend was applied to the data. Over the course of the test, the corrected drawdown for a time x would be,

$$\text{Corrected drawdown} = \text{drawdown} + (\text{BE}) \, [(\text{Patm initial} - y) / 0.4335 \text{ psi/ft}]$$

The required corrections were found to be approximately 0.03 feet of water or less for the drawdown and recovery phases. This represents a maximum of 5 percent (and in most cases much less) of the measured water level change for the test. Therefore, no water level correction for barometric pressure changes was necessary for the PTW-6 test.

Figure 4-5

PTW-1 Test Barometric Pressure Corrections

Figure 4-6 shows the trend of the barometric pressure during the PTW-1 drawdown and recovery tests. A linear regression is provided with the line fit shown on the figure:

$$y = -2.0E\text{-}5x + 14.67 \text{ psi}$$

where y = barometric pressure, and x = elapsed time in minutes.

The overall trend shows a decrease in barometric pressure over the time of the test. The increase is rather small as evidenced by the slope of the line, -2.0E-5. However, during the course of the test, the atmospheric pressure decrease would cause a decrease in the water level drawdown and an increase in the water levels during recovery.

Using the BE of 0.6 derived above, this average trend was applied to the data. Over the course of the test, the corrected drawdown for a time x would be,

$$\text{Corrected drawdown} = \text{drawdown} + (\text{BE}) \left[(\text{Patm initial} - y) / 0.4335 \text{ psi/ft}\right]$$

The required corrections were found to be approximately 0.06 to 0.10 feet of water for the drawdown and recovery phases. This represents a significant change (as much as approximately 20 percent) that required correction of the measured water levels during the test. The corrected drawdown and recovery data were then analyzed for aquifer properties.

Figure 4-6

4.2.4 Pumping Rate

For the PTW-6 test, the rate was monitored frequently throughout the test to make sure that a constant rate was maintained. The average rate was relatively constant at 37.8 gpm. The total volume pumped was 75,821 gallons over the 33.4 hour pumping period.

For the PTW-1 test, the rate was monitored at frequent intervals, and the average rate was relatively constant at 36.7 gpm. The pumping duration was 33.43 hours. The total amount of water pumped was 73,562 gallons.

4.2.5 Water Level Changes Resulting from Pumpage

Water Level Changes in the PTW-6 Test

Starting with the pre-test background period and ending with the recovery after the PTW-6 test, water levels were monitored and recorded continuously in digital form in all of the BMW wells using Level Troll data loggers. Levels in PTW-5, OMW-8, and OMW-9 were also recorded with Troll units. Water levels in PTW-6, PTW-4, PTW-3, and RBLB-3 were recorded digitally with the Hermit device.

The water level changes recorded with the Troll data loggers during the PTW-6 test are shown in Figure 4-7. Figure 4-8 shows the water level response in the pumping well and three nearby observation wells. Note that the vertical scale is logarithmic in Figure 4-8. Water levels were recorded more frequently at the beginning of the drawdown and the recovery portions and the sampling time increment was increased as the test progressed (see Section 4.1.3). As discussed in Section 4.1.3, manual water levels were also recorded primarily for quality assurance purposes. The actual analyses were performed on the continuously recorded digital data.

Figure 4-7

Figure 4-8

From Figures 4-7 and 4-8, it can be seen that at least 0.6 feet of drawdown was recorded in all of the observation wells with drawdown as high as 2.2 feet in some of the wells. This amount of drawdown is considerably more than the amount of water level change that can be attributed to barometric pressure changes (Section 4.2.3). Note that the vertical scale is logarithmic in Figure 4.8.

The PTW-6 test digital logger data are given in Tables 4.1 and 4.2. The manual measurements are given in Table 4.3. These tables can be found in Appendix D.

Water Level Changes in the PTW-1 Test

Starting with the pumping in PTW-1, water levels were monitored continuously in all of the BMW wells using Level Troll data loggers. Water levels were measured in all of the OMW wells during this phase of the PA-1 testing. OMW 1 to 9 measurements were made manually. OMW-2 measurements were obtained with the level troll transducer for the pre pumping test portion. OMW-1 water levels were recorded with the Hermit device. The water level changes during the PTW-1 test are shown in Figure 4-9 for the Troll data and Figure 4-10 for the Hermit data.

From Figures 4-9 and 4-10, it can be seen that at least 0.85 feet of drawdown was recorded in all of the observation wells with drawdown as high as approximately 1.85 feet in some of the wells. This amount of drawdown is considerably more than the amount of water level change that can be attributed to barometric pressure changes (Section 4.2.3).

The PTW-1 test digital logger data are given in Tables 4.4 and 4.5. The manual measurements are given in Table 4.6. These tables can be found in Appendix D.

Figure 4-9

Figure 4-10

4.2.6 Hydraulic Communication between Pumped Wells and Observation Wells

The drawdown response to pumping is a measure of the amount of hydraulic communication between wells. Excellent communication between the pumped wells and the observations wells in the baseline monitoring well ring was observed in both tests. This means that the production zone baseline monitoring wells will communicate effectively with the PA-1 production area and therefore serve their intended function as monitor wells to protect water quality.

As discussed in the previous sections, the water level response to pumping was significantly greater than what could be attributed to barometric pressure changes. Also, as discussed below, the drawdown response in the monitoring ring wells was analyzable for aquifer parameters. This provides evidence that the observation well response to pumping is not simply the result of background fluctuations that could be caused by long term or seasonal water level fluctuations due to natural recharge or discharge. Furthermore, the water level changes are clearly induced by the pumpage at PTW-1 and PTW-6.

4.2.7 Hydrologic Communication between Aquifers

The pumping tests in PTW-1 and PTW-6 demonstrate that there is no communication between the overlying Sand A aquifer and B sand aquifers. This is based on the water level response in the OMW series wells. Sand A is in the depth range of approximately 50 to 120 feet below ground level and the OMW wells are completed within this interval. Sand B wells are deeper, with typical completions in the 160 to 200 feet depth range.

In Figure 4-7, there is no discernable response in OMW-8 and OMW-9 to the pumping in PTW-6. The trace of the responses in OMW-8 and OMW-9 are superposed and fluctuate slightly around the 0 water level point. The response in the other wells to the pumpage is quite clear in Figure 4-7. Figure 4-10 shows that there was a very slight increase in water levels in OMW-1 during the PTW-1 test. If there were hydraulic communication between the pumped Sand B and Sand A, there would be an obvious decline in the water level of OMW-1.

Manual water level measurements in the OMW wells given in Tables 4.3 and 4.6 have a similar pattern. There is no detectable response in the overlying Sand A to the Sand B pumpage in either the PTW-1 or the PTW-6 test.

4.2.8 Transmissivity and Storativity Calculations

The well tests were analyzed using Aqtesolv for Windows, Version 4.50 Professional (Duffield, 2007). This commercial program has been successfully and widely used for well test analysis since 1996.

The well test analyses are given in Appendix D for the PTW-6 and the PTW-1 tests. Each pumping and observation well is analyzed separately and there may be multiple analyses for a given well. A graph of the data with the line fit is given for each analysis. There are two phases for each test: water level drawdown during pumping, and water level recovery after the pumping well is shut-in. The goal of the analysis is to determine the transmissivity and storativity of the aquifer at each well location.

Well Test Analysis Methodology

The PTW-6 and PTW-1 tests were analyzed using standard hydrologic methods. Three different standard methods were used to analyze the PTW-6 drawdown tests: Theis, Cooper-Jacob, and Dougherty Babu (PTW-6 only). Antother standard method, the Theis recovery method, was used to analyze the recovery portion of the PTW-6 test.

Prior to the PTW-1 test analysis, the data were corrected for barometric pressure effects. Then, the Theis method with superposition was used to analyze the PTW-1 test drawdown and recovery results. This is because there was prior pumping in PTW-6. This prior pumping was incorporated into the analysis.

Well Test Analysis Results

The data were analyzable using the standard techniques described above. The expected Theis response was clearly displayed in the data. This means that the tests were properly conducted and that results can be used to characterize the Sand B aquifer.

The results are summarized in Table 4.7. The results between the two tests are similar. The transmissivity appears to be somewhat higher in the region near BMW-12 to BMW-22. The storativity is relatively constant. The analysis show that the transmissivity range is from approximately 377 to 1521 ft^2/day. The storativity ranges from approximately 0.00001 to 0.001. The storativity was anomalously low in PTW-6 from the first test. This may be an artifact of perturbations in the data from the pumping well.

4.3 Hydrologic Boundaries and Recharge Areas

4.3.1 Hydrologic Boundaries

The recovery data from the PTW-1 pumping well may indicate the presence of a no flow boundary or an area of reduced transmissivity. As shown in Figure 4-11, there is a noticeable increase in the slope of the recovery data starting about 30 minutes after pumping stopped.

Table 4.7

Figure 4.11

4.3.2 Recharge Boundaries and Recharge Areas

No indications of recharge boundaries were found in the test data. Recharge areas for the A and B sands are located in outcropping areas to the west of the proposed mine. Recharge is by direct precipitation on the outcrop. No indication of any major regional recharge boundaries to the northwest where found in the pumping test data.

4.4 Summary of Conclusions

The first goal of the test was to confirm that there is hydraulic communication between the monitoring well ring and the wells within the production zone sand (Sand B). This was clearly achieved in both tests. This indicates that the production zone monitor wells will be able to detect fluid movement from where uranium recovery is occurring (the production zone). Measures will be taken to prevent such an occurrence. During recovery operations, a net drawdown or “bleed” will be maintained in the ore zone by producing (i.e., removing) approximately 1% more water than the amount being injected. This means that there will be a hydraulic barrier to prevent fluid from moving out of the production zone. As an added measure of safety, water quality in the monitor wells must be monitored throughout the recovery and restoration phases of the operation.

The second goal was to analyze the pumping test results. This was done to characterize the aquifer and obtain data on the aquifer’s hydraulic characteristics such as transmissivity, storativity, and hydraulic conductivity. The data were of good quality and were analyzed using standard hydrologic techniques. The analysis shows that the transmissivity range is from approximately 377 to 1521 ft^2/day. The storativity ranges from approximately 0.00001 to 0.001. Finally, no communication was observed between Sand B and the overlying Sand A.

4.5 References

Duffield, G. M., 2007, Aqtesolv for Windows, Version 4.50 Professional, Hydrosolv Inc., Reston, VA.

Domenico, P. A. and F. W. Schwartz, 1990, Physical and Chemical Hydrogeology, John Wiley and Sons, New York, 824 p.

Freeze, R. A. and J. A. Cherry, 1979, Groundwater, Prentice Hall, New Jersey, 604 p.

Todd, D. K., 1980, Groundwater Hydrology, John Wiley and Sons, New York, 535 p.

5.0 Groundwater Quality

5.1 First Overlying Aquifer (Sand A)

Table 5.1 lists water quality values for nine monitor wells completed in Sand A which is the first overlying aquifer above the production zone (Sand B). There are no other aquifers above Sand A. In addition to showing individual water quality values for 26 constituents, Table 5.1 provides summary statistics on high, low and averages values, and where applicable, the standard deviation is given.

For South Texas, water quality in Sand A is relatively good; however, it does not meet EPA Drinking Water Standards. Table 5.1 shows that values for Total Dissolved Solids (TDS) and Arsenic (As) are in excess the standards; the average value for TDS 904 mg/l and the average concentration for As is 0.018 mg/l. EPA Drinking Water Standards for these constituents are 500 mg/l and 0.010 mg/l, respectively. When comparing the 904 mg/l average TDS value to Texas' 1000 mg/l Standard, it is apparent that water quality for this parameter is near the higher end of this standard.

Although the average value for a particular constituent is an important measure of water quality, the presence and frequency of high values must also be considered in the evaluation. Referring back to Table 5.1, for example, it can be seen that 33% (every third well) of the wells have TDS values that exceed the 1000 mg/l Texas Standard. Although on average the water quality is within the Texas Standard for TDS, it is not uncommon for a well to have values that exceed this standard. When a standard is more stringent, the frequency of occurances above the standard can be expected to increase, especially given the variability in groundwater. To illustrate, Table 5.1 shows that 100% of the wells have TDS values that are significantly higher than the EPA 500 mg/l level. Similarly, with the exception of one well (OMW-5), all of the wells have arsenic values in excess of the EPA Drinking Water Standard. Well OMW-5 has a value that is right at the 0.01 mg/l Drinking Water Standard and 33% of the wells have values that are at least twice the standard.

Examination of radium-226 values serves as another example of how a specific parameter can vary within a small portion of an aquifer. Radium-226 has a range from 0.5 pCi/l to 6.0 pCi/l – the high value is 12 times higher than the low value, and a Standard Deviation that is nearly 83% of the average.

Table 5.1 Overlying Aquifer (Sand A) Water Quality

Table 5.1 Overlying Aquifer (Sand A) Water Quality

One well (OMW-4) exceeds the EPA Drinking Water Standard of 5.0 pCi/l, and the values recorded in wells OMW-5 (3.6 pCi/l) and OMW-8 (4.8 pCi/l) are significantly above typical baseline levels of <1.0 pCi/l. The 2.3 pCi/l average value for radium-226 matches the average value from 47 area wells that were sampled in the baseline water well inventory in late 2006. Although the averages are the same, it should be remembered that the completion zones for many of the area wells are not known. Without knowing the completion zones, a direct comparison cannot be made.

To summarize, Sand A water quality does not meet EPA's Primary Drinking Water Standards for TDS and arsenic. Elevated arsenic levels in the Gulf Coast Aquifer, including sites in Goliad County, are acknowledged in the 2008 State of Texas Water Quality Inventory Groundwater assessment (March 19, 2008). Page 105 of the study states, "As with the Ogallala aquifer, the Gulf Coast aquifer shares some concern over the presence of arsenic." Figure 8 (page 107) from the study shows that sites in northern and southern Goliad County have arsenic levels in excess of the 1.0 mg/l EPA Primary Drinking Water Standard.

The 5.26 mg/l average nitrate level is somewhat elevated compared to many areas of Texas but it is within EPA's 10 mg/l Primary Drinking Water Standard. Nitrate levels at or in excess of the 10 mg/l standard were reported in six wells during the 2006 water well inventory. Elevated nitrate levels are also noted for areas within the Gulf Coast Aquifer in the 2008 State of Texas Water Quality Inventory Groundwater assessment (March 19, 2008). With regard to EPA Secondary Drinking Water Standards, the average chloride value of 266 mg/l slightly exceeds the 250 mg/l standard.

In the upcoming section discussing one of the more strongly mineralized portions of the aquifer, Sand B Production Zone, it will be shown that there is a pronounced difference in water quality between Sand A and Sand B. In view of the conclusions given in Chapter 3.0 Production Area Geology and Hydrology and Chapter 4.0 Hydrologic Testing, it is not surprising to find distinct water quality differences between the two sands. Hydrologic testing verified that the substantial clay/shale confining layers described in the geology chapter effectively isolate the two sands from each other - without these effective barriers, the two sands would have similar water quality.

Evaluation of the deeper subsurface geology shows significant confining layers between the base of Sand C and the top of Sand D. As demonstrated in the Mine Permit Application, Sand D too is adequately confined at its top and base with clay/shale layers.

5.2 Production Zone (Sand B)

For the purposes of hydrologic testing and baseline characterization, 18 wells were completed in Production Zone Sand B. As of August 2008, 10 of the wells had been sampled, and the results were included in the PAA application at that time. Anticipating that an additional 8 wells would be installed and made ready for sampling by September of 2008, UEC had requested TCEQ to observe the sampling event and to collect split samples from any of the baseline wells. After receiving the laboratory results on the additional 8 wells and completing a quality assurance/quality control review, UEC supplemented the production zone baseline water quality section of the application with the expanded database.

Figure 1-4 Production Area Map has been updated to show the location of all baseline wells associated with proposed PA-1, including 2 proposed Guard Wells. The wells labeled PTW-1 through PTW-14 and RBLB-1, 3, 4 and 5 are completed in Sand B. As can be seen from the map, the wells are distributed in a pattern that provides coverage throughout the production area. Covering the area in this manner not only provided a better basis for characterizing the water quality, it also provided a wider array of well locations for hydrologic testing (well pumping).

Water quality analyses for the 36-acre Production Area are presented in Table 5.2. A review of the table shows that the water quality fails to meet EPA Primary Drinking Water Standards; TDS, and more importantly uranium and radium-226, are in excess of the standards. Although the average TDS value of 636 mg/l exceeds EPA's 500 mg/l by approximately 138 mg/l, it is the presence of uranium and radium-226 that sets this water quality far apart from water quality that is deemed acceptable for human consumption. Because this 36 acre portion of the aquifer contains natural uranium mineralization, elevated levels of uranium and radium-226 are to be expected; it is the presence of these elements, and to a lesser extent several other constituents which are discussed below, that make Sand B quite different from overlying Sand A.

Table 5.2 Production Zone (Sand B) Water Quality

Table 5.2 Production Zone (Sand B) Water Quality

Of the 18 Production Zone Sand B wells, 72% have uranium concentrations in excess of the EPA Drinking Water Standard of 0.030 mg/l. The average for all 18 wells is 0.115 mg/l or 3.8 times the standard. With regard to radium-226, 100% of the wells are in excess of the 5 pCi/l standard. The lowest radium-226 values were recorded in PTW-1, PTW-2 and PTW-13. The values for these wells are 17 pCi/l for both PTW-1 and PTW-2 and 10 pCi/l for PTW-13. Other production area wells have values far in excess of the 5 pCi/l standard. The average radium-226 concentration is 334 pCi/l, which is 67 times higher than the EPA Primary Drinking Water Standard of 5 pCi/l. The lowest radium-226 value of 10 pCi/l is two times higher than the drinking water standard and the highest value of 1,684 exceeds the drinking water standard by 337 times.

In summary, the Sand B aquifer does not meet EPA Primary Drinking Water Standards. Moreover, because of its high radium-226 content, water from this zone would not be suitable for long-term irrigated agriculture. Watering of livestock from this zone should also be avoided, especially since much higher quality water is locally present throughout the non-mineralized portions of the aquifer.

5.3 Mine Area (Sand B Perimeter Monitor Wells)

Referring back again to Figure 1-4 Production Area Map, the Production Zone Monitor Ring can be seen in relation to the 36- acre Production Area. The area encompassed by the monitor well ring is approximately 94 acres. All 22 wells were sampled and analyzed for the same 26 water quality constituents given in the tables for Sand A Non-production Zone and Sand B Production Zone. Not unexpectedly, the subsequent discussion will show that baseline water quality in the Mine Area is more similar to that in the Production Area. Since the Mine Area wells (i.e., those in the Production Zone Monitor Well Ring) are completed in Sand B, water quality should be quite similar; however, the levels of uranium and radium-226 should not be as high as they are in the Production Area.

Table 5.3 summarizes the water quality values for the 22 production zone monitor wells. It is immediately obvious from the table that the water quality in the Mine Area also fails to meet EPA Primary Drinking Water Standards. Unlike Sand B Production Zone, the Mine Area meets the drinking water standard for uranium; however, it does not meet the 5 pCi/l drinking water standard for radium-226.

Table 5.3 Baseline Monitor Wells (Production Zone)

Pages 5-9 through 5-14

Mine Area water quality also falls short of meeting EPA's Primary Drinking Water Standard for TDS. The average TDS value for the Mine Area is 652 mg/l and the EPA standard is 500 mg/l. The lowest TDS value of 575 mg/l occurred in a single well (BMW-2).

It was previously mentioned that for certain parameters water quality can vary noticeably within an aquifer, and the range of variability for a constituent can be significant over a relatively short distance. A comparison of radium-226 values from the Production Zone with those in the Mine Area provides a good illustration of this point. The average radium-226 level in the monitor well ring is 28 times lower than the average in the Production Area. The monitor well ring average is 12 pCi/l compared to 334 pCi/l in the Production Area which is only 400 feet from the ring. Although radium-226 is considerably lower at a distance of 400 feet from the Production Area, many of the monitor wells have significantly elevated levels. Table 5.3 shows that approximately 45% of the monitor wells have radium-226 in excess of the drinking water standard. Eighteen percent of the wells exceed the 0.03 mg/l drinking water standard for uranium, and one of the monitor wells (BMW-9) is more than 6 times higher than the standard. Again, because the monitor well ring is located very near a delineated ore zone, values such as those listed in the tables are to be expected.

5.4 Water Quality Comparisons

Now that water quality information has been presented for all three zones, a single summary table has been prepared to allow an overall one-page comparison.

At the risk of being repetitive, the water quality comparisons given in Table 5.4 clearly show the significant variability in groundwater from the same aquifer. With the exception of considerably higher radium-226 levels in Production Area, water quality in the Production Area is quite similar to that in the Mine Area. Since wells from these areas are completed in the Production Zone Sand B, similarity can be expected. The main difference between the two areas is that commercial quantities of recoverable uranium are concentrated in the Production Area. However, as discussed above, significant portions of the Production Zone Monitor Well Ring (Mine Area), also have uranium mineralization but the main ore body lies approximately 400 feet inside the ring.

Table 5.4 Water Quality Comparisons (Overlying Non-Production Area Sand A, Production Area Sand B, and Mine Area)

Clearly the biggest water quality difference shown on Table 5.4 is between the Overlying Non-production Sand A and the two areas within Production Zone Sand B (Production Area and Mine Area). Major differences can be seen in 9 of the water quality indicators listed below.

Sand A, the shallowest of the aquifers, has significant levels of nitrate compared to Sand B. The precipitous decline in nitrate levels from Sand A to the lower Sand B is yet another example of the hydraulic separation that exists between the two sands. Significant differences in chloride and TDS are additional indicators of the isolation between the two zones. At the PA-1 location in the proposed permit area, Sand A does not have strong uranium mineralization, and this is another indication that the sands are effectively isolated from one another. Because of their isolation, differences in certain water quality constituents are expected.

Lastly, it should be remembered from earlier discussions in this chapter that Sand A fails to meet EPA Primary Drinking Water Standards for two non-radiological constituents: TDS and arsenic. Unlike Sand A, Production Sand B fails to meet the drinking water standards for one non-radiological parameter (TDS) and two radiological parameters: radium-226 and uranium.

	Sand A Non-Production Zone	Sand B Production Area	Sand B Mine Area
Calcium (mg/l)	184	97	97
Sulfate (mg/l)	99	41	58
Chloride 9mg/l)	266	163	165
Nitrate (mg/l)	5.26	0.41	0.01
TDS* (mg/l)	904	636	652
Arsenic (mg/l)	0.018	0.011	0.008
Molybdenum (mg/l)	0.012	0.037	0.035
Uranium (mg/l)	0.009	0.115	0.020
Radium-226 (pCi/l)	2.3	334	12

*Total Dissolved Solids.

Up to this point the discussion has focused on the number and location of wells sampled, water quality differences, comparisons with drinking water standards, production area and mine area size, etc. Although all of these important and interesting topics are required elements of the PAA Application, additional information on water levels and TDS variability across the proposed Production Area must also be included in the Application. To that end, four maps are included herein: (1) Production Zone TDS Contours Map; (2) Non-production Zone TDS Contour Map; (3) Production Zone Piezometric Map; and (4) Non-production Zone Piezometric Map.

Figure 5-1 Production Zone TDS Contour Map was constructed using TDS from the 22 monitor wells and the 10 interior production zone wells. TDS values from the nine overlying Sand A wells were used in making Figure 5-2 Non-production Zone TDS Contour Map. Similarly, the piezometric maps were made from water level measurements taken from the baseline wells when hydrologic testing was performed in June and July of this year.

Figures 5-1 through 5-4 TDS Contour Maps and Piezometric Maps Sand A and Sand B

Pages 5-19 through 5-22

6.0 Proposed Restoration Table, Monitor Well Designations and Upper Control Parameters

6.1 Groundwater Analysis Report Summary

As required by TCEQ, water quality values for the baseline wells must be given in a table provided by the agency titled Groundwater Analysis Report Summary: this requirement has been followed, and the water quality values for (1) the Non-production Zone (overlying Sand A); (2) Mine Zone Production Area; and (3) Production Area (Sand B) are summarized in Table 6.1. The well identification for each area is also included in the table.

6.2 Proposed Restoration Table

Using the values from Table 6.1, a proposed Restoration Table was prepared. Table 6.2 is the proposed Restoration Table. The revised table was developed in accordance with the revised rules of March 12, 2009 regarding restoration table values (30 TAC §331.104 and §331.107).

6.3 Designated Monitor Wells

The designated monitor wells are listed in Table 6.3.

6.4 Designated Baseline Wells

Designated baseline wells are given in Table 6.4.

6.5 Proposed Upper Limits Control Parameters

By far, the best parameters for indicating a change in water quality associated with in situ recovery or restoration operations are chloride and conductivity. These parameters not only provide the earliest indication of a possible excursion, they are also easy to measure, and changes can be quickly detected. In other words, they provide an immediate and reliable measure of change in water quality, and this in turn allows an operator to take corrective measures as soon as possible.

In the past, uranium was included as a third indicator for possibly suggesting that an excursion has occurred, but there was no scientific basis to support it as a proper indicator.

Table 6.1 Groundwater Analysis Report Summary

Table 6.2 Proposed Restoration Table

Calcium	97
Magnesium	16.2
Sodium	102
Potassium	7.1
Carbonate	0.0
Bicarbonate	332
Sulfate	41
Chloride	163
Fluoride	0.64
Nitrate-N	0.41
Silica	26.4
pH (Standard Units)	7.30 to 7.96
TDS	636
Conductivity (μmhos/cm)	1044
Alkalinity	272
Ammonia-N*	<0.1
Arsenic	0.011
Cadmium*	<0.005
Iron	0.038
Lead*	<0.012
Manganese	0.015
Mercury*	<0.0004
Molybdenum	0.037
Selenium	0.002
Uranium	0.115
Radium-226 (pCi/l)	333.8

All units are mg/l unless otherwise noted.
*These elements do not occur naturally in the aquifer and they are not part of the recovery process. In addition, these parameters have been exhaustively sampled throughout the history of ISR in Texas and shown to be nearly non-existent. Ammonia-N was used at a few project sites during the infancy of the industry but its use was discontinued. Since ammonia is no longer used in ISR operations, it should be removed from the restoration table. The other items (Cadmium, Lead and Mercury) too should be removed for the reasons just noted.

As indicated on Table 6.2 Proposed Restoration Table, ammonia, cadmium, lead and mercury do not naturally occur in the aquifer. A review of the baseline sampling analyses clearly shows this to be the case. It is also mentioned in the footnotes on Table 6.2, that these elements have been sampled exhaustively over the years at other ISR project sites and the record underscores the fact that they do not occur in the aquifers. When ammonia was briefly used at a few sites many years ago, it was certainly an appropriate element for monitoring and for restoration. However, since it is no longer used, there is no reason to include it in the list of pertinent elements.

In accordance with the revised rules, UEC requests that ammonia, cadmium, lead and mercury be excluded from the proposed restoration table. According to 30 TAC 331.104(b), any parameter except uranium and radium-226 may be excluded from a restoration table. In making a decision on this matter, the executive director may consider the following:

1. the element(s) does not naturally occur in the aquifer;
2. the element(s) are not included in the injection solution;
3. the element(s) are not dissolved by the mining process; or
4. any other applicable information provided by the applicant or permittee to support the exclusion of certain elements.

UEC believes that all four of the above points of consideration have been met: the elements do not occur in the production zone; the elements are not included in the proposed injection solution; because the elements are not in the aquifer, they are not subject to being dissolved by mining solutions; and lastly, extensive water quality sampling shows that these elements are not in the aquifer.

Table 6.3 Designated Monitor Wells

Non-production Zone Overlying Sand A	**Production Zone Monitor Wells (Mine Area)**	**Production Zone Monitor Wells (Mine Area)**	**Production Zone Monitor Wells (Mine Area)**
OMW-1	BMW-1	BMW-10	BMW-19
OMW-2	BMW-2	BMW-11	BMW-20
OMW-3	BMW-3	BMW-12	BMW-21
OMW-4	BMW-4	BMW-13	BMW-22
OMW-5	BMW-5	BMW-14	
OMW-6	BMW-6	BMW-15	
OMW-7	BMW-7	BMW-16	
OMW-8	BMW-8	BMW-17	
OMW-9	BMW-9	BMW-18	

Table 6.4 Designated Production Zone Baseline Wells (Production Area)

PTW-1
PTW-2
PTW-3
PTW-4
PTW-5
PTW-6
PTW-7
PTW-8
PTW-9
PTW-10
PTW-11
PTW-12
PTW-13
PTW-14
RBLB-1
PBLB-3
RBLB-4
RBLB-5

Over the history of in situ uranium recovery in Texas, thousands of water samples that were routinely collected from hundreds of monitor wells rarely showed elevated uranium or radium-226. When excursions were detected, the indicators were invariably conductivity and chloride.

The use of uranium as an indicator parameter has come to the attention of the Nuclear Regulatory Commission (NRC). After evaluating it, NRC does not recommend using it as an indicator to detect excursions (see NUREG-1569, Nuclear Regulatory Commission's Standard Review Plan for In Situ Leach Uranium Extraction License Applications, Final Report, June 2003).

UEC is proposing to use the two best indicators (chloride and conductivity) for the Upper Limits Control Parameters. Using chloride and conductivity will provide the earliest warning of a possible excursion. UEC is also proposing that if an excursion is indicated by reaching or exceeding an upper control limit, part of the corrective action would include analyzing the water for uranium, radium-226 and other water quality constituents, as may be requested by TCEQ.

Table 6.5 lists the proposed upper control limits. The values given in Table 6.5 were derived by adding 25% to the highest value recorded in the production zone monitor wells. Non-production zone values were derived by adding 25% to the highest value recorded in overlying Sand A.

Table 6.5 Proposed Upper Limits Control Parameters

Production Area-1 (Overlying Sand A) Non-production Zone

Chloride: 730 mg/l
Conductivity: 3,062 μmhos

Production Area-1 (Production Zone Sand B)

Chloride: 210 mg/l
Conductivity: 1,450 μmhos

7.0 Updated Mine Plan

7.1 Mine Plan Description

During the past year, UEC has made refinements to the nature of the ore zones. To illustrate, the production area acreage for Sand B was initially estimated to be approximately 25.6 acres; following additional evaluation, production Sand B in PA-1 has been increased to just over 36 acres and Figure 7-1 Permit Map has been updated to show the size and shape of PA-1. The figure has also been updated to show: (1) the production zone monitor well ring; (2) the buffer area between the monitor well ring and the permit/lease boundary; (3) other proposed production areas and their respective acreages; (4) the proposed location of the production facility; and (5) the proposed locations of the waste disposal wells. The updated production and restoration schedules for the mine areas are described in Section 7.2.

7.2 Updated Production and Restoration Schedule

An updated production and restoration schedule has been prepared and is given in Table 7.1 When compared to the estimate given when the Mine Permit Application was submitted to TCEQ, it can be seen that the start date for production is now estimated to begin in 2010. The original estimate showed an estimated start date in the fourth quarter of 2009. The schedule has also been updated to include one year stability periods. As far as operational changes during are concerned, there are no significant changes at this time. The projected new startup date and one year stability period for restoration are the only significant changes.

Figure 7-1 Permit Map

Table 7.1 Updated Production and Restoration Schedule

7.3 Restoration Progress Report

Since the project has yet to begin, there is no restoration progress to report. However, a brief summary of UEC's restoration procedures and plans for reporting restoration progress are outlined in the following discussion.

The technology for restoring groundwater to levels consistent with baseline involves using native groundwater sweep and reverse osmosis (R.O). The effectiveness of current-day restoration has been enhanced by many years of experience. Two major improvements include: 1) initiating restoration as soon as possible following uranium recovery in a given production area and 2) using R.O. during the mining process to keep competing ions from becoming too elevated.

A vital step in achieving successful restoration is to establish representative baseline water quality within the area where uranium will be recovered. In the early days of the industry not enough attention was given to developing a baseline that was representative of the area to be mined. Instead of establishing an adequate number of baseline wells in the potential mine area (the area that must be restored to pre-mining uses), production area baseline wells were inadvertently completed outside the mineralized area; as a result, average, low and high values established for baseline were not representative of the mineralized zone. Because a disproportionate number of baseline wells were completed in the non-mineralized zone this had the obvious affect of mischaracterizing the actual water quality of the mine area. Because of improper placement of wells, baseline conditions in the production area were erroneously shown to be of higher quality, and this in turn set up artificially low restoration targets for a number of constituents and made it impossible to achieve the desired goals. Recognizing this flaw, operators are now making an effort to properly characterize pre-mining groundwater quality in the areas where production will likely occur.

Given the backdrop just described, UEC diligently delineated the production area and constructed a baseline well pattern to properly characterize background water quality conditions. The groundwater quality analyses from this plan support the proposed Restoration Table goals.

UEC plans to use R.O. during the uranium recovery phase to minimize the elevation of competing ions. In doing this, uranium recovery efficiency will be enhanced and water quality will be maintained at a higher level. Maintaining a higher level of water quality during the recovery phase will allow restoration to proceed more quickly and effectively. Restoration and restoration progress will be in accordance with the terms specified in the permit (see Sections G.3, G.4 and G.5.d).

7.4 Updated Fluid Handling Requirements vs. Capacity

Because information on the first production area has been further refined, the overall fluid balance shown on Table 7.2 Updated Fluid Handling Requirement vs. Capacity was re-examined for possible adjustments. Given that the estimates in the table must be based on the estimated maximum operational/restoration capacity, the refinements made to PA-1 do not result in any significant change to Table 7.2. As stated in Section 7.2 above, the main change in the schedule is due to an estimated new startup date and the one year stability period for restoration. Apart from this change, the fluid handling requirements and capacity information given in the Mine Permit Application remains valid.

Table 7.2

8.0 **Financial Security**

According to § 27.073 (a-1), A person to whom an in situ uranium mining injection well, monitoring well, or production well permit is issued shall be required by the commission to maintain a performance bond or other form of financial security to ensure that an abandoned well is properly plugged. Detailed requirements concerning financial surety are given in Title 30 of the Texas Administrative Code ("30 TAC") Chapter 331. According to Subchapter A, § 331.15 Financial Assurance Required, injection is prohibited for Class I and Class III wells which lack financial assurance. Chapter 37, Subchapter Q, § 37.7021 of 30 TAC requires an owner or operator subject to this subchapter to establish financial assurance for plugging and abandonment of Class III wells. Chapter 37, Subchapter Q, Financial Assurance for Underground Injection Control Wells establishes the requirements for demonstrating financial assurance for plugging and abandonment (s*ee* 30 TAC § 37.7001). Finally, additional financial assurance requirements are detailed in 30 TAC Subchapter I, §§ 331.142, 331.143 and 331.144. These rules require a permittee to: (1) secure and maintain adequate surety for plugging and abandonment as specified in Chapter 37, Subchapter Q; (2) prepare a plugging and abandonment cost estimate reflecting the period in the operation's life when plugging and abandonment would be most expensive; and (3) maintain the latest cost estimate as prepared under § 331.143(a) during the operational life of the project; and (4) certify and obtain certification from an independent licensed professional engineer or licensed professional geoscientist that plugging and abandonment have been accomplished in accordance with an approved plugging and abandonment plan.

Additionally, at least 60 days prior to drilling wells, UEC will post a form of financial assurance listed in 30 TAC § 37.7021. At this time, UEC anticipates that the surety mechanism would be: (1) a fully funded or pay-in trust; (2) a surety bond guaranteeing payment; (3) a surety bond guaranteeing performance; or (4) an irrevocable standby letter of credit.

During operations, UEC will submit plugging and abandonment cost estimates for the anticipated number of wells needed as the project goes forward. The cost estimates will be in current dollars and will include labor, materials, equipment and supplies.

For PA-1, it is anticipated that the wells listed in Table 8-1 will be needed. As the table shows, 18 production zone baseline wells and 22 production zone monitor wells are in place, and it is estimated that 192 injection and recovery wells will be needed for operations in PA-1.

With respect to total depth and casing size, the proposed injectors and extractors will be completed at an average total depth of approximately 200 feet below ground level, and the well casing will be 6 inch diameter PVC. For the existing wells, actual total depths are known, and these depths are summarized in Table 8-2.

Table 8.1 Wells Existing and Planned for PA-1

Injectors/ Extractors	Overlying Monitor Wells	Production Zone Baseline Wells	Production Zone Monitor Wells
192*	9**	18**	22**

*To be completed.
** Existing

Revised: March 27, 2009

Table 8.2 Total Depth of Existing Wells in PA-1

	Depth (Feet)		Depth (Feet)		Depth (Feet)		Depth (Feet)
OMW-1	97	BMW-1	209	BMW-10	194	BMW-19	218
OMW-2	110	BMW-2	206	BMW-11	183	BMW-20	200
OMW-3	106	BMW-3	205	BMW-12	180	BMW-21	206
OMW-4	119	BMW-4	193	BMW-13	188	BMW-22	208
OMW-5	120	BMW-5	204	BMW-14	206		
OMW-6	123	BMW-6	201	BMW-15	210		
OMW-7	119	BMW-7	199	BMW-16	206		
OMW-8	119	BMW-8	195	BMW-17	191		
OMW-9	113	BMW-9	197	BMW-18	212		
PTW-1	190						
PTW-2	211						
PTW-3	210						
PTW-4	208						
PTW-5	207						
PTW-6	206						
PTW-7	201						
PTW-8	216						
PTW-9	206						
PTW-10	210						
PTW-11	206						
PTW-12	215						
PTW-13	216						
PTW-14	228						
RBLB-1	205						
RBLB-3	220						
RBLB-4	205						
RBLB-5	183						

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A well plugging and abandonment cost estimate is provided in Table 8.3. Information in support of the estimate is summarized in Table 8.4. The estimate is based on current costs and a 20% contingency is included.

With the adoption of new rules as of March 12, 2009, applicants are required to provide a cost estimate for groundwater restoration in a production area authorization application. UEC has completed a detailed cost estimate and it is summarized in Table 8.5.